Proposal for the Space-borne Integrated Path Differential Absorption (IPDA) Lidar for Lower Tropospheric Water Vapor Observations

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Measurements of water vapor profiles are very important in the studies of atmospheric dynamics, clouds, aerosols, and radiation. Water vapor is the predominant greenhouse gas and its vertical distributions are important in the global climate system. Water vapor data would lead to benefits in numerical weather prediction, such as localized heavy rainfall events and typhoon forecasting. The DIAL (Differential Absorption Lidar) technique is most available to perform high-resolution measurements of tropospheric water vapor distributions from space.

We have proposed a two-beam spaceborne water vapor DIAL with the OPA (Optical Parametric Amplifier) transmitter using the 1350-nm absorption band. OPA system using QPM (Quasi Phase Matching) device is one path amplifier; OPA is advantageous for space use because it has less restrictions than conventional phase-matching OPO (Optical Parametric Oscillator). An error simulation is performed assuming that the platform altitude is 250km (super-low altitude satellite), the receiver diameter is 0.8m, the laser energy is 20mJ, and the repetition rate of the laser shot pair (on-off) is 500Hz. It has been shown that less than 10% water vapor profile measurement relative error is possible between 0.3-2km altitudes with spatial resolutions of 300m vertically and 20km horizontally in East Asia in summer.

As well as the vertical water vapor distribution, measuring the amount of water vapor near the sea surface is important for forecasting heavy rainfall and estimating the flux between the ocean and the atmosphere. Therefore, without changing the specifications of the proposed DIAL mission, we investigated a possibility of DIAL observations of lower tropospheric and near surface water vapor using both signals of the atmospheric backscattering and the surface reflection by employing the integrated path differential absorption (IPDA) technique. This technique uses the differential absorption of the signal reflected by the surface, which is stronger than the atmospheric backscattering signal. It has been shown that less than 10% measurement relative error for water vapor between 0-200m altitudes is possible with a horizontal resolution of 20km.